

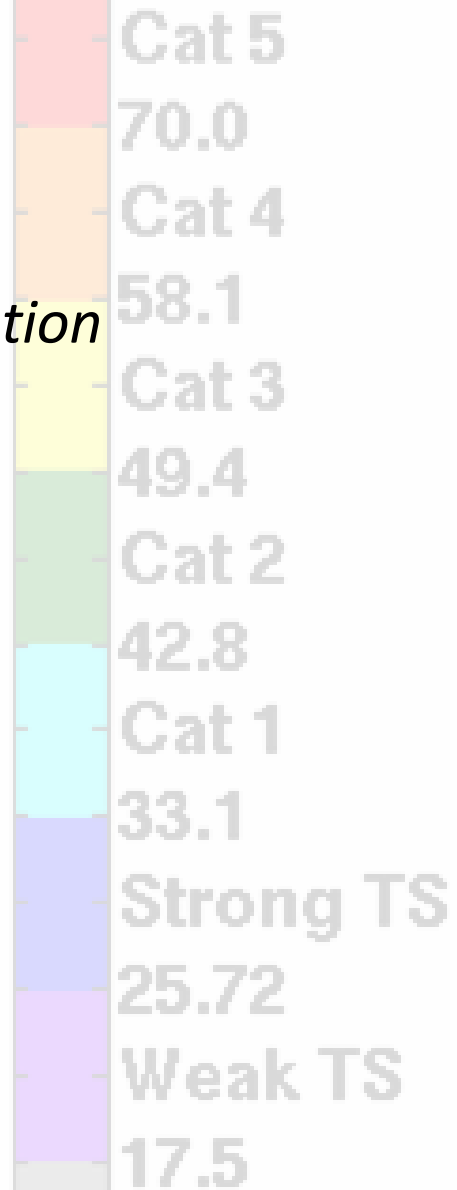
# Hurricane Imaging Radiometer (HIRAD)

**Daniel J. Cecil**, *NASA Marshall Space Flight Center*

**Sayak K. Biswas**, *Universities Space Research Association*

**W. Linwood Jones**, *University of Central Florida*

*Daniel.J.Cecil@nasa.gov*



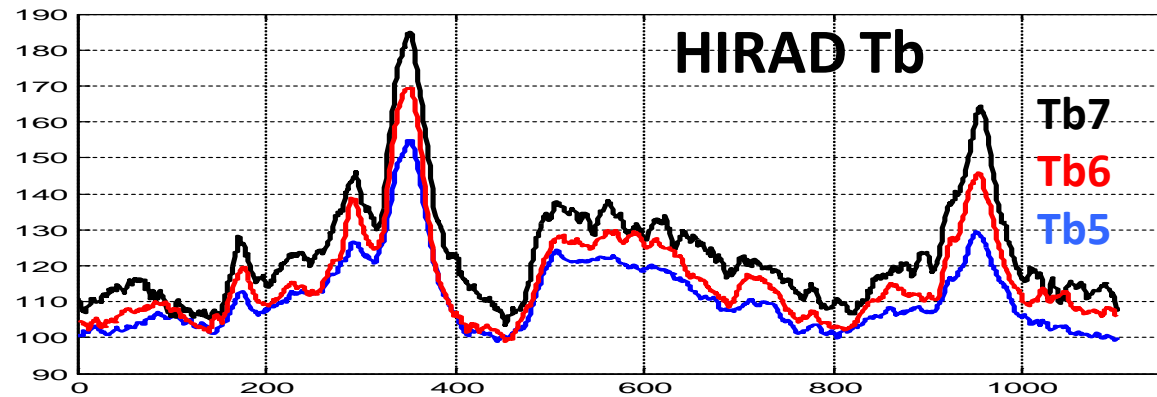
C-band (4, 5, 6, 6.6 GHz)  
radiometer

Retrieval concept similar to  
the operational Stepped  
Frequency Microwave  
Radiometer (SFMR)

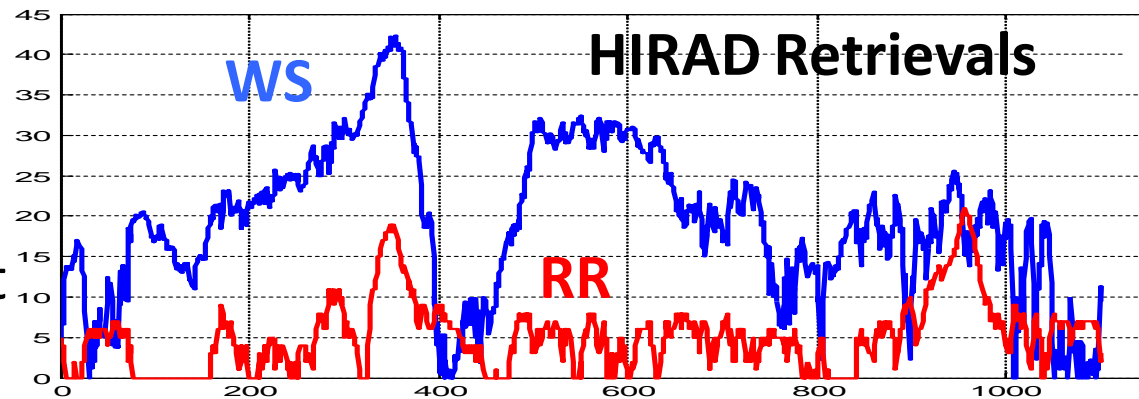
**Retrieve Wind Speed and  
Rain Rate over ocean, *but  
over a wide swath***

C-band frequencies have  
varying sensitivity to rain but  
~equal sensitivity to wind  
speed (emission from foam  
on wind-roughened ocean  
surface)

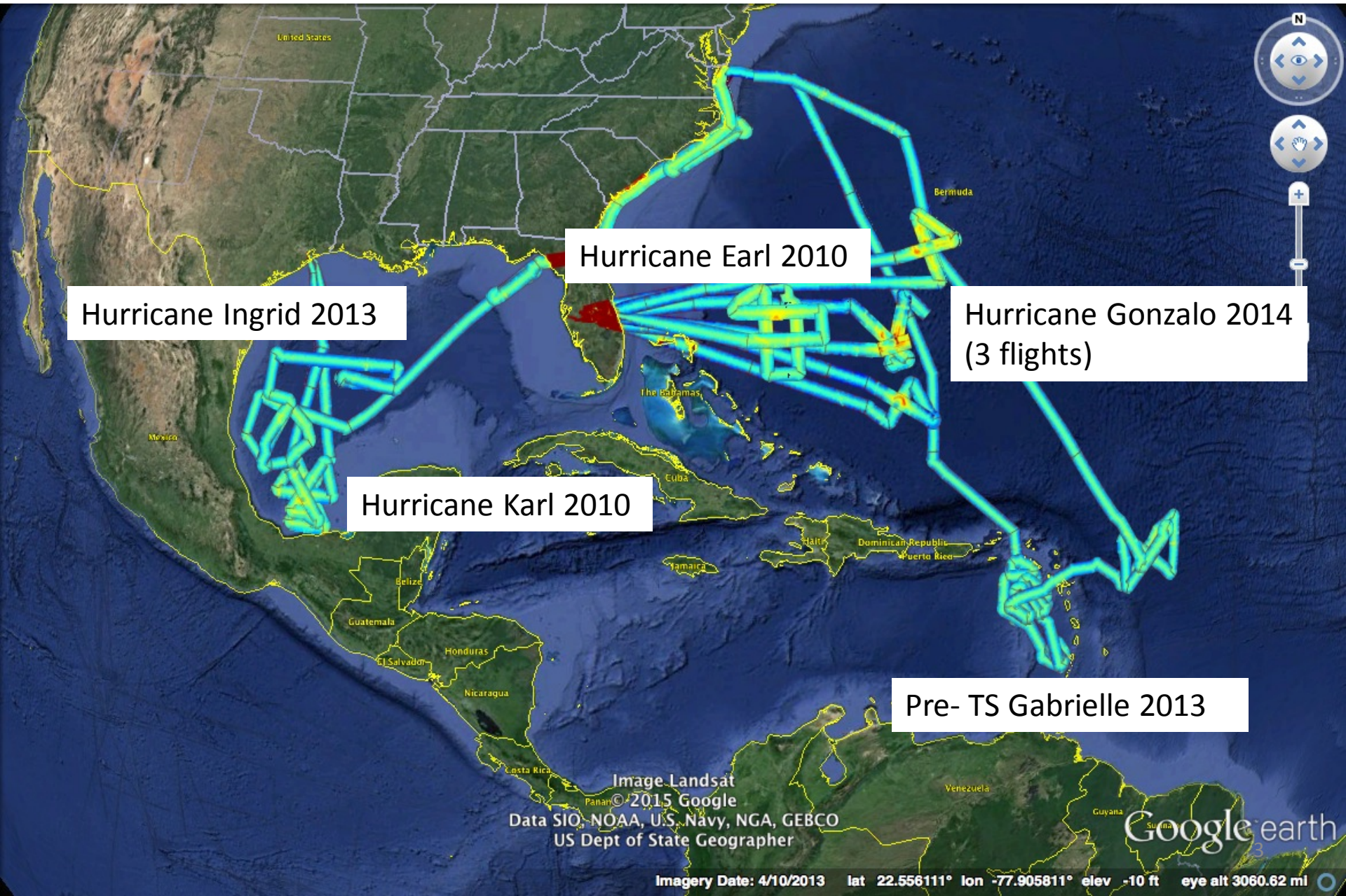
# HIRAD Background



*Hurricane Karl (2010) example*

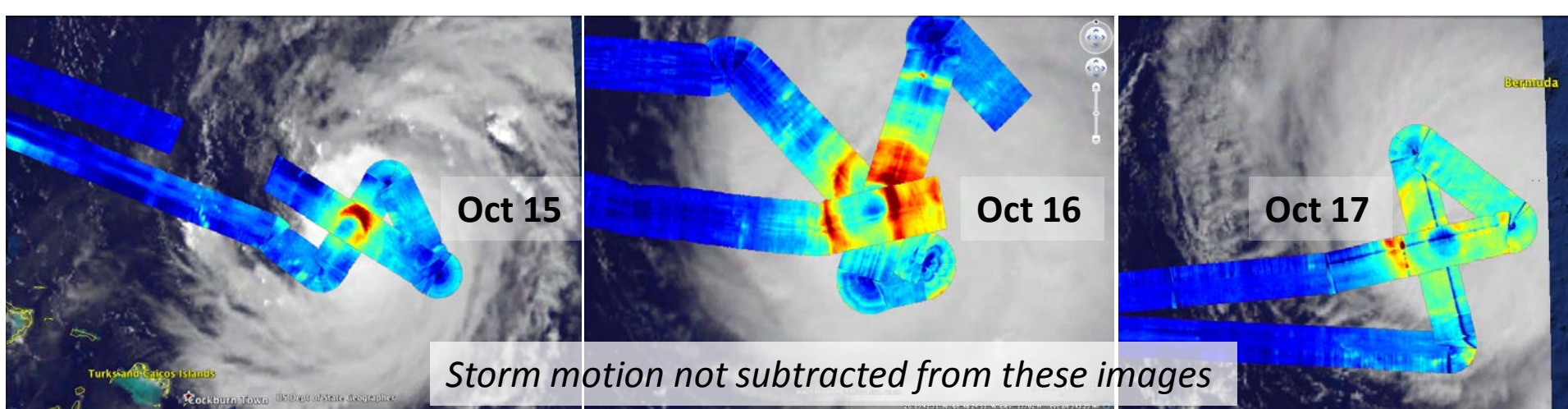


# HIRAD Science Flights





# Hurricane Gonzalo (2014)

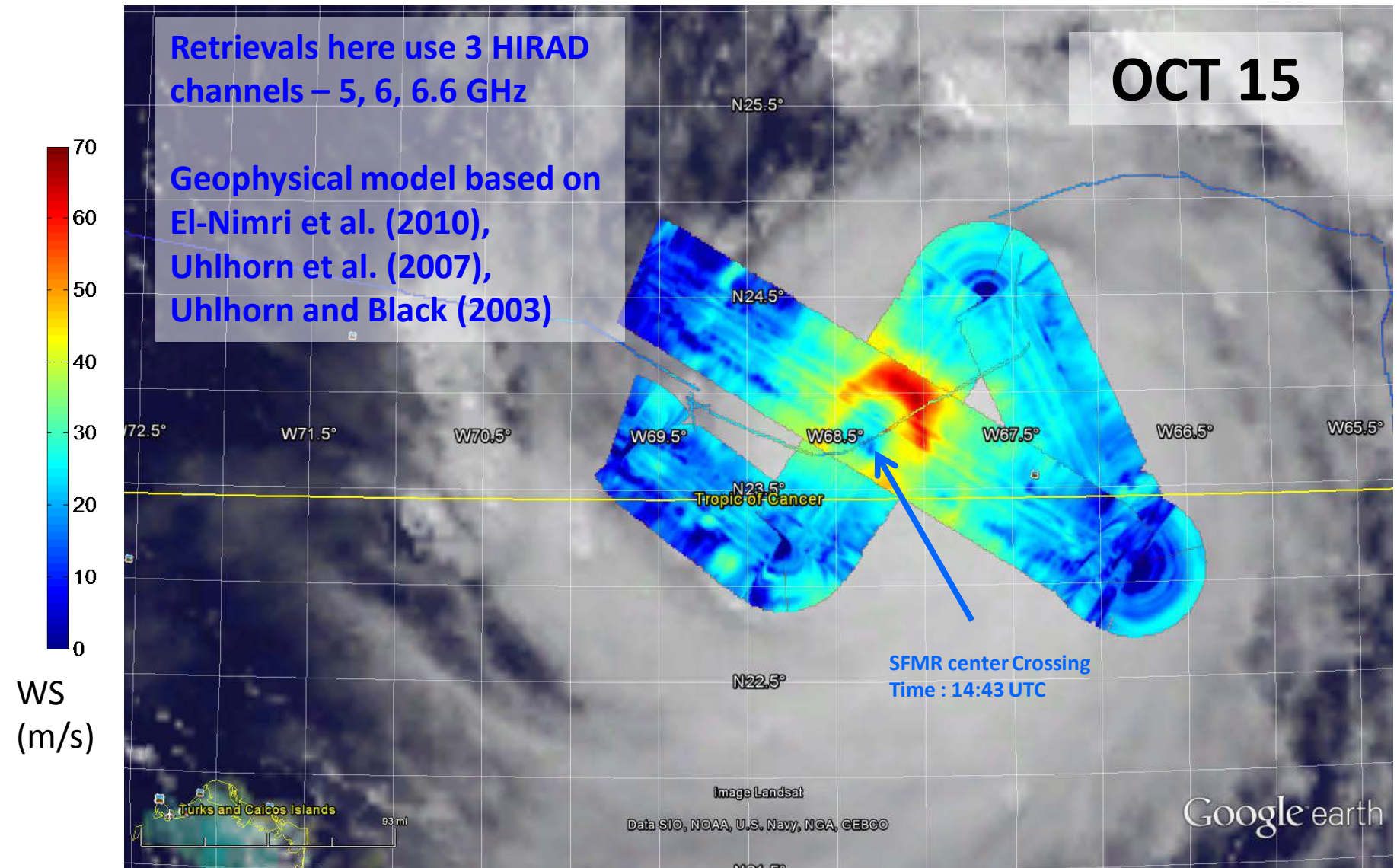


Flown on NASA WB-57 based out of Houston, forward-deployed to Tampa

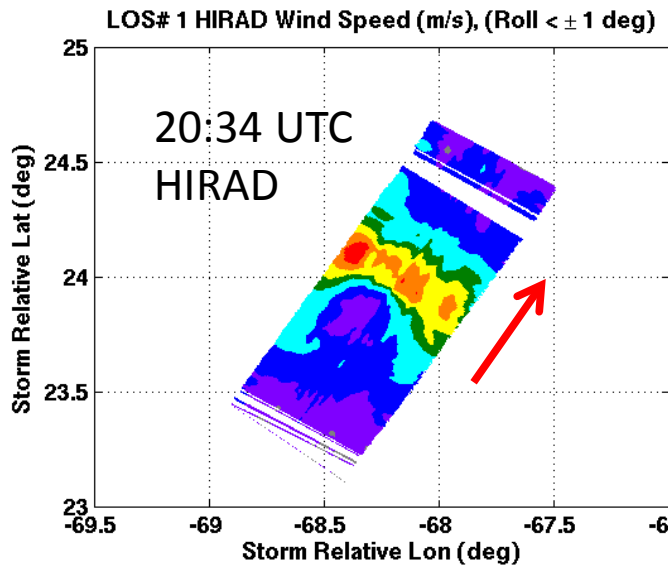
Cooperation between NASA HS3 program and ONR TCI program

Instruments were integrated onto Global Hawk AV-1 in July for HS3, but AV-1 was unable to perform missions. WB-57 was available for hurricane flights because of the ONR program, so HIRAD and HIWRAP were moved from Global Hawk to WB-57. Kudos to all who made this switch possible!

# Center Crossings at 20:34 and 21:12 UTC



# Wind Retrievals – Oct 15 Gonzalo

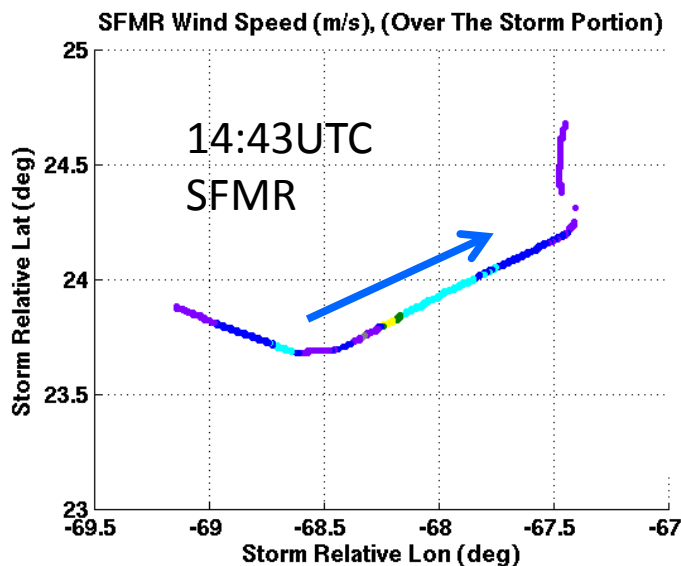
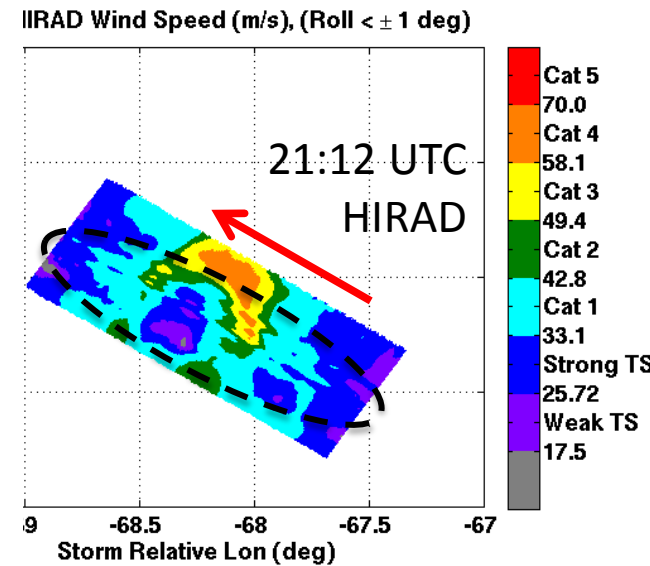


HIRAD has biases at some incidence angles, seen as along-track striping.

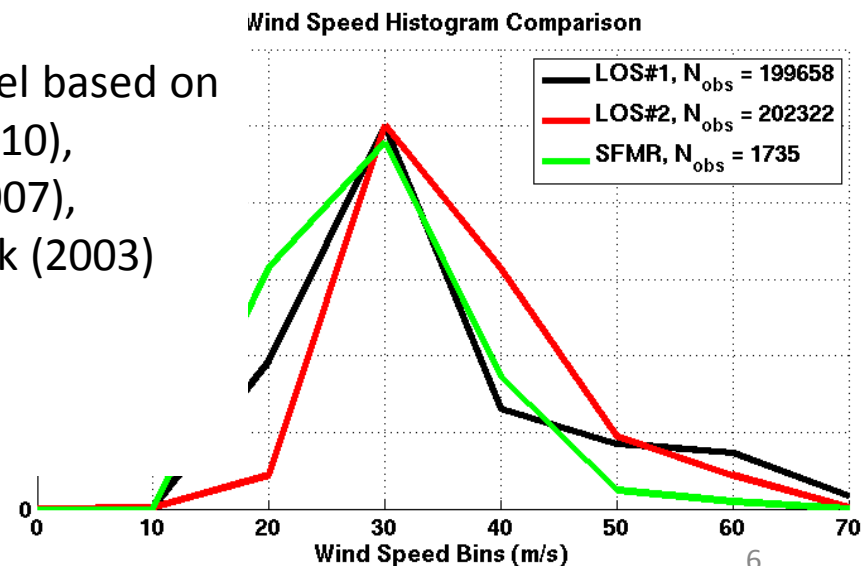
Also tends to be high-biased along left edge.

Work in progress

Retrievals here use 3 HIRAD channels – 5, 6, 6.6 GHz

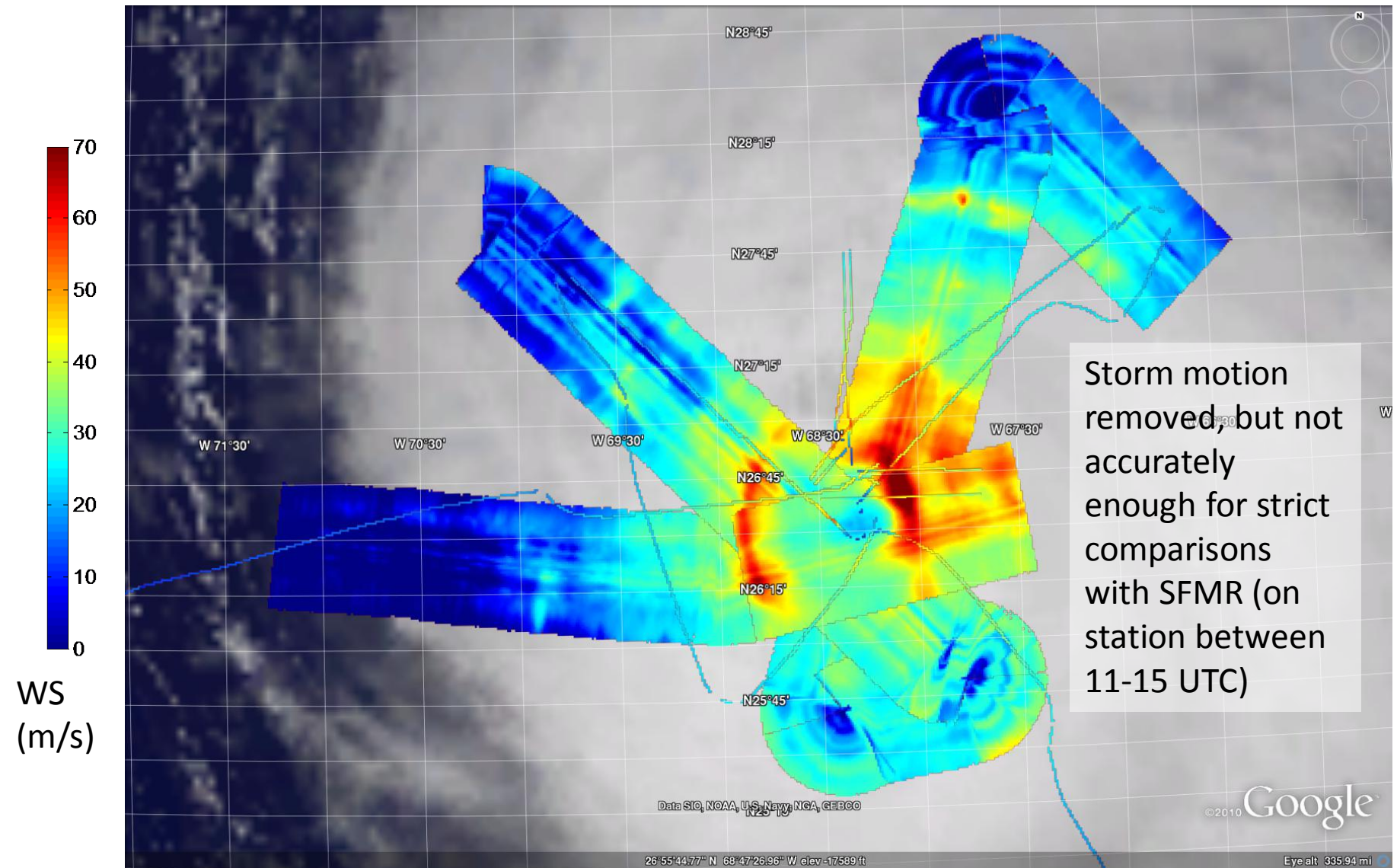


Geophysical model based on El-Nimri et al. (2010), Uhlhorn et al. (2007), Uhlhorn and Black (2003)





# Oct 16 Center at 1711, 1803, 1825 UTC



# HIRAD Wind Retrieval, 16 Oct 2014 Gonzalo

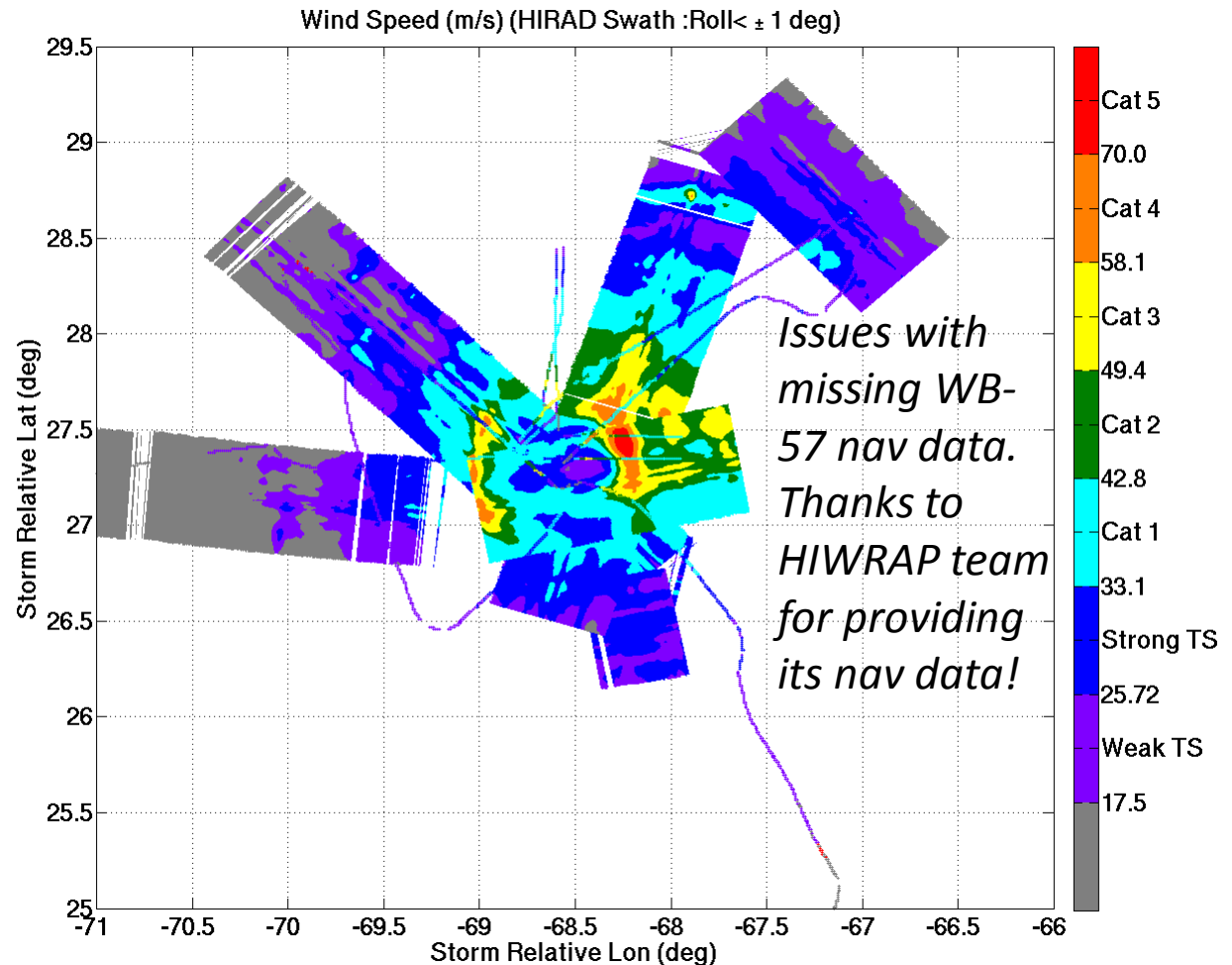
Along-track striping more pronounced, more difficult to remove than on other days

Our heaters turned on with inappropriate set points during this flight, making 16 Oct data difficult to handle

Some issues with removal of storm motion in this imagery, but correctable

The inner-core looks muddled here, but that I apparently because:

- an inner eyewall was strong on East and Northeast sides, weak elsewhere
- an outer eyewall was strong on West side, weak on South side

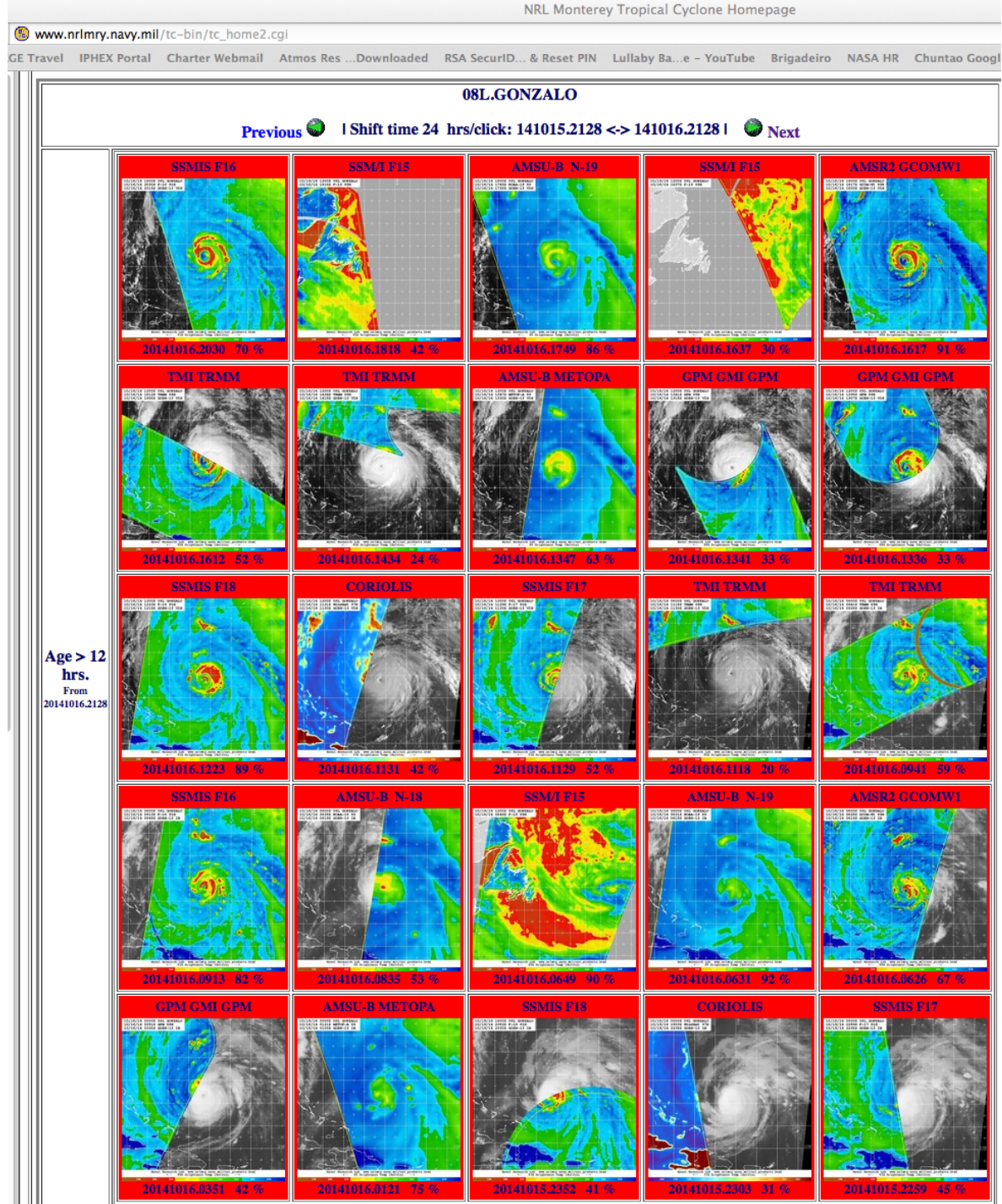




# Eyewall Replacement Cycle during 16 Oct 2014 for Gonzalo

*85-89 GHz Mosaic  
from NRL MRY TC  
Web Page*

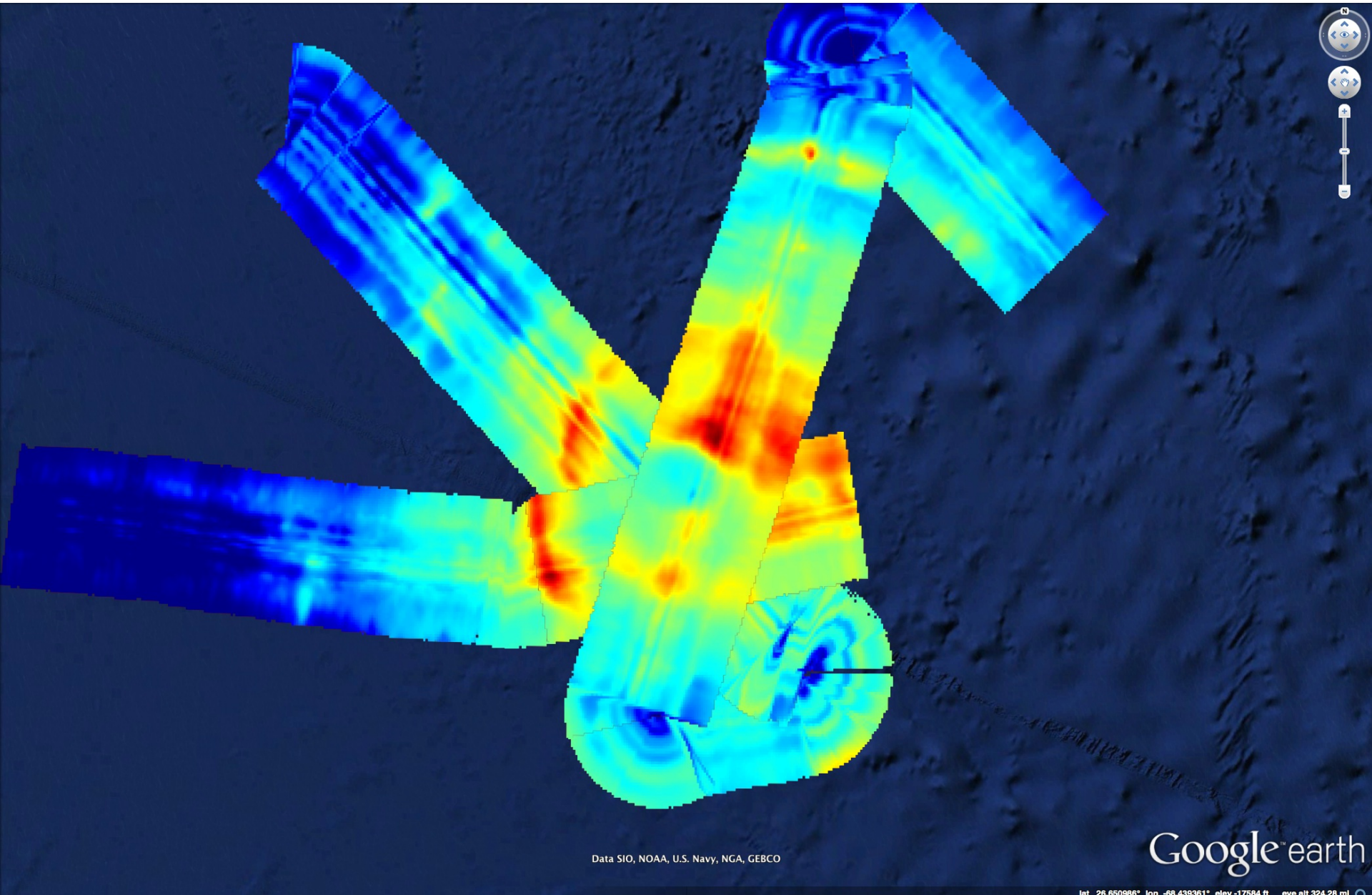
*WB57 on station  
~1700-1830 UTC,  
top row of  
overpasses*



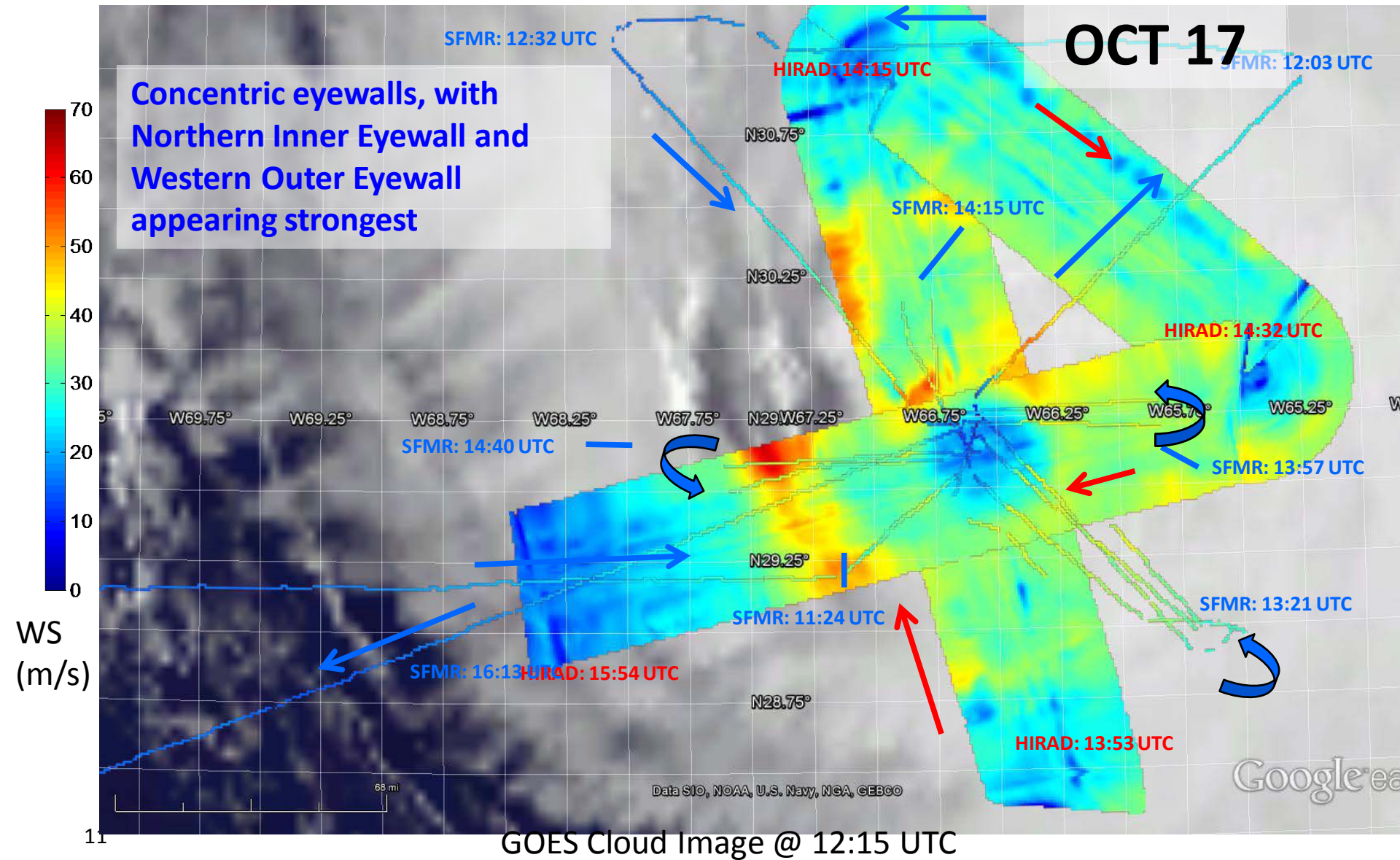


# AMSR2 89 GHz at 1617 UTC 16 Oct

## HIRAD at 1711, 1803, 1825 UTC



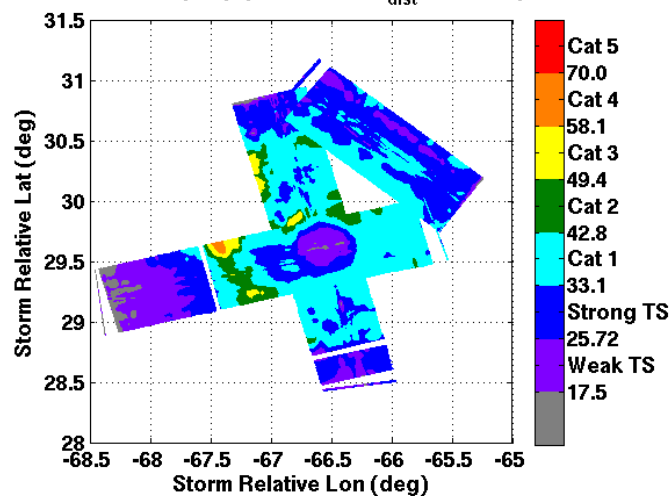
# Center Crossings at 14:04 and 14:41 UTC



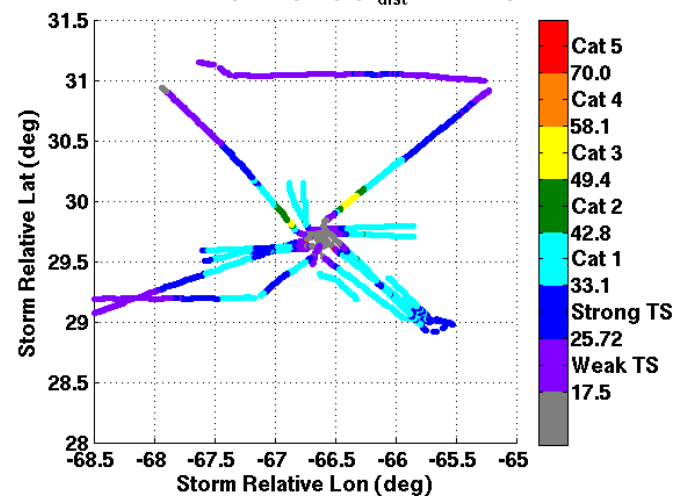


# Wind Retrievals – Oct 17 Gonzalo

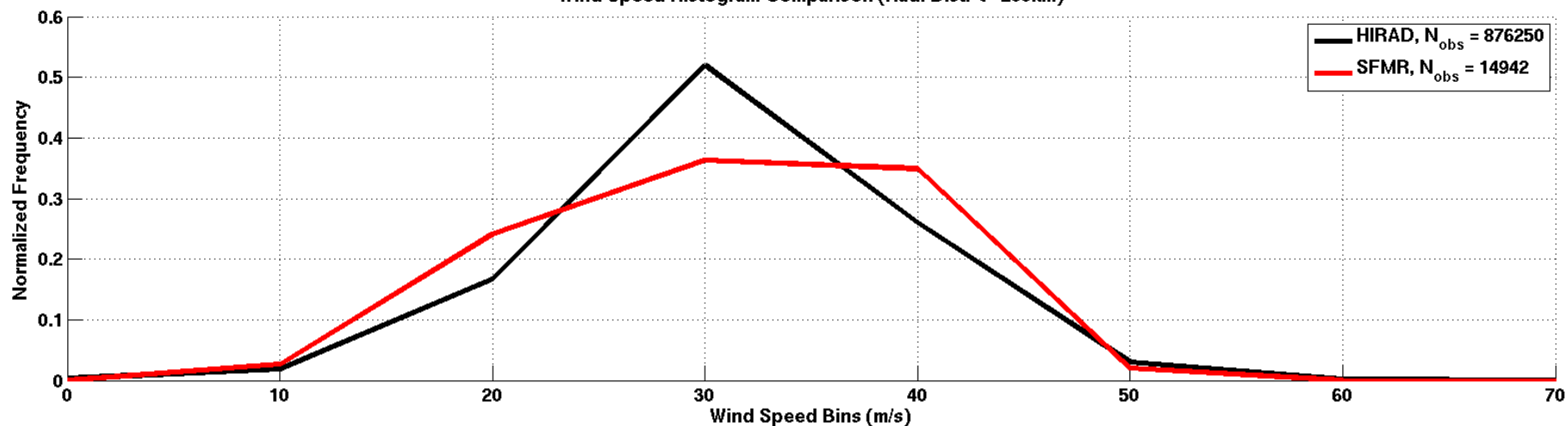
HIRAD WS(m/s), (Roll  $\leq \pm 1^\circ$ ,  $R_{\text{dist}} \leq 200\text{km}$ )



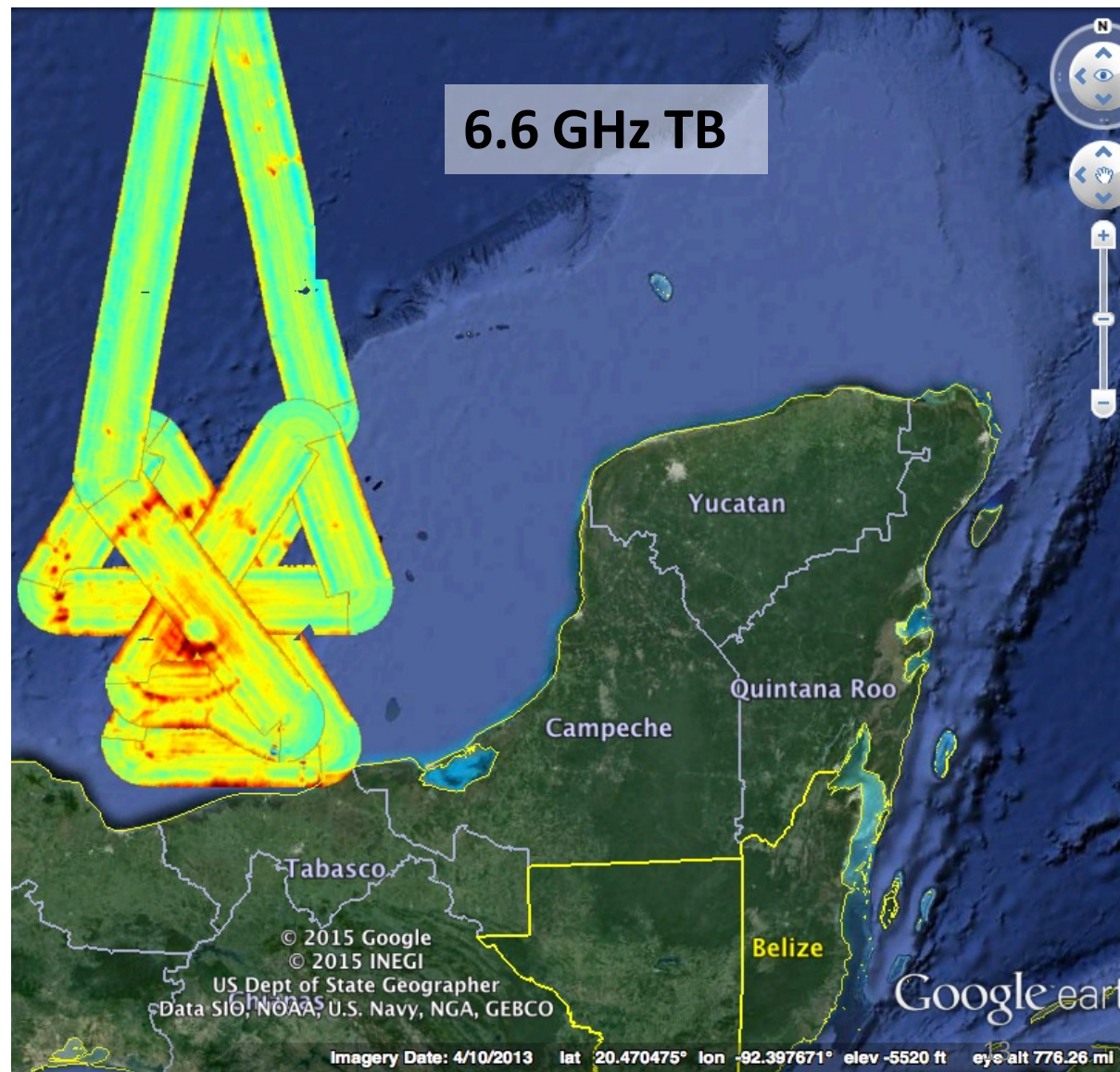
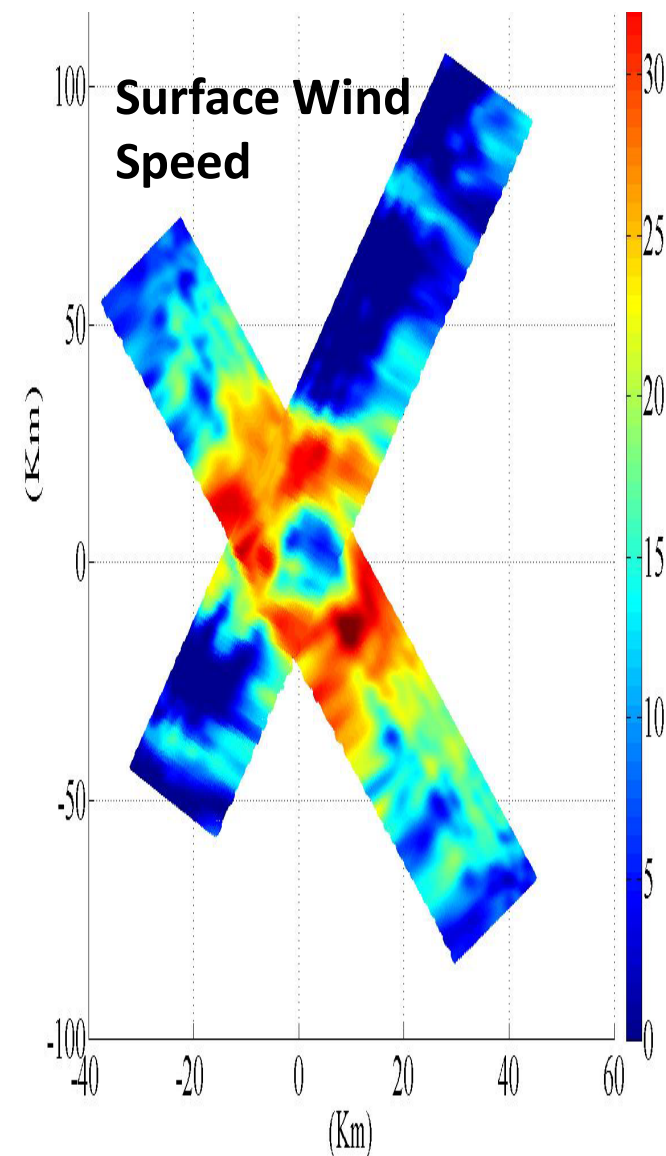
SFMR Wind Speed (m/s), ( $R_{\text{dist}} \leq 200\text{km}$ )



Wind Speed Histogram Comparison (Rad. Dist.  $\leq 200\text{km}$ )



# Hurricane Karl (2010) Brightness Temp and Wind Speed Retrieval



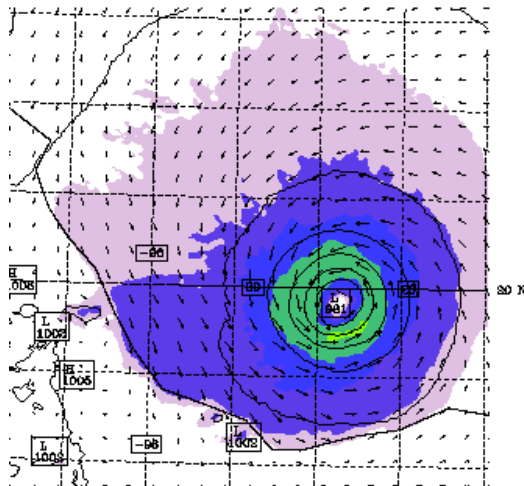
# HIRAD Wind Retrieval, Assimilation for Hurricane Karl

Surface wind field in data assimilation experiments from Jason Sippel at GSFC

Adding HIRAD (bottom middle) improves characterization of asymmetric nature of wind field, and correctly reduces the horizontal extent of the wind field. Control and Control+HIWRAP(radar) experiments had Radii of 50-kt and 34-kt winds too large, compared to Best Track

Best results from assimilating Dropsonde, HIRAD, HIWRAP together

**HIWRAP VAD wind assimilated**





# Summary

- 3 Science Flights from WB-57 over Hurricane Gonzalo (2014)
- Wide-swath data helps paint a picture of hurricane structure
- Initial retrievals from Oct 15, Oct 17 flights look good, some systematic (scan-angle dependent) biases remaining
- Oct 16 data has more striping, but hurricane structure is there – eyewall replacement in progress
- Hurricane Karl (2010) wind retrievals tested in assimilation with dropsondes and HIWRAP; improved structure of wind radii

